High-Quality Code

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Practical Aspects of Software Design, BUT FIT, 2021-05-05

Outline

Introduction

A tale of two libraries

1. The first library:
   - Very poor documentation
   - Trouble with compilation because of missing dependencies
   - Segfaults when given a file without an extension
   - Calls `exit()` when encountering an error
   - Sometimes prints output to `stdout`/`stderr`
   - Hard to change because of unreadable code and missing tests
2. The second library:
   - Amazing documentation
   - Seamless integration, automatic resolving of missing dependencies
   - Crystal-clear interface
   - Proper error handling and propagation of errors
   - Readable code that makes modifications a breeze
   - Code is completely covered by tests

Which one would you use? Which one do you write? ;-)

What is high-quality code?

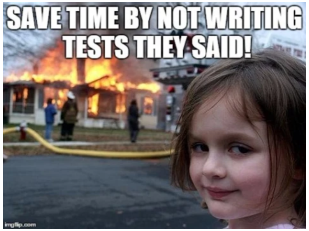
- Correct
- Robust, anticipates and handles edge cases and errors
- Safe and secure
- Well designed and organized without being over-engineered
- Readable, easy to change, allows sustainable development
- Testable and covered by tests
- Thoroughly documented
- Efficient without being prematurely optimized

Notes:

- Everything is connected
- Code quality is not binary or absolute
- Perfection is not attainable

Why do we strive to write high-quality code?

- To satisfy our users and employers
- To save time and money
- To prevent catastrophes or security breaches
- Code is written only once but read/modified many times
- To show that we are true professionals
- Thinking of your fellow programmers (or your future self)



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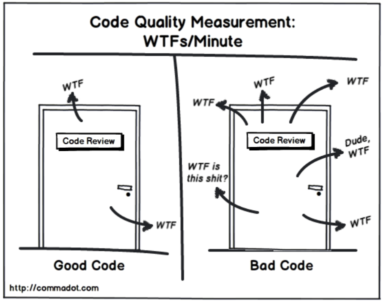
How to measure code quality?



Another measure: How easy is to correctly change the code.

What to focus on

Code correctness

- What is correctness?
- Correctness with respect to what?
- Absolutely correct code
- Understand functional requirements
- Understand non-functional requirements

Code robustness and error handling

- One of the hardest part of software development
- Robust programming
  - Paranoia
  - Stupidity
  - Cannot happen
- Be conservative in what you send, be liberal in what you accept
- Anything that might happen will happen, handle all edge cases
- Understand what might fail, handle all errors

```c
int fclose(FILE *stream);
```

- Understand error-handling mechanisms
- Propagating errors upwards

Code safety and security

- Safety vs security
- Buffer overflows, crashes

```
char buf[BUFSIZE];
std::cin >> buf; // gets(buf);
```

- Thread (un)safety, common concurrency issues
- Resource leaks
- Improper handling of inputs

```
$id = $_GET['id'];
$sql = "SELECT * FROM users WHERE id = $id";
$result = $mysqli->query($sql);
```

- Understand common safety and security flaws

Code readability, extensibility, and maintainability

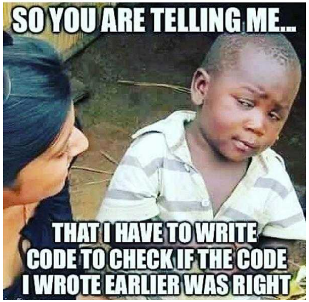
- Great, descriptive naming
- Consistency is key
- Split code into smaller functions/classes
- Keep code at a single level of abstraction

```
if ((currentDate() - user.getBirthDate()) >= Years(18))
// vs
if (user.isOldEnoughToDrink())
```

- Logical organization of functions, classes, modules, packages
- High cohesion, low coupling
- Comments explaining *why*
- Understandable is better than clever
- Learn design principles and patterns (e.g. SOLID, some GoF patterns)

Code covered by tests

- Why do we write tests?
- Untested code does not work
- Selected types of tests:
  - Unit tests
  - Integration tests
  - End to end tests
  - Performance tests
  - Compatibility tests
- Code coverage
- Continuous integration
- Testing the UI
- Testing examples in the documentation


SO YOU ARE TELLING ME...
THAT I HAVE TO WRITE CODE TO CHECK IF THE CODE I WROTE EARLIER WAS RIGHT

https://bit.ly/3nCt01e

Testability

- Code has to be testable
- Learning how to write testable code takes time
- An example technique: Dependency injection

```java
public class Service {
    private DBConn dbConn;

    public Service(Config config) {
        dbConn = new PostgreSQLConn(config);
    }
    // vs
    public Service(DBConn dbConn) {
        this.dbConn = dbConn;
    }
}
```

- Tests improve your code
- Consider writing tests first

Documentation

- The bane of programmers
- Everybody wants to have it, nobody wants to write it
- User vs development documentation
- Important to keep up-to-date
- Although outdated documentation is better than no documentation

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Knowledge of the used programming language(s)

- Syntax and semantics
- Abstractions
- Memory management
- Language idioms

```
i = 0
while i < len(items):
    print(items[i])
    i += 1
# vs
for item in items:
    print(item)
```

- Different implementations, OS specifics
- Common pitfalls
- Strengths and weaknesses, when to use a particular language

Knowledge of the used libraries

- Learn what is provided by standard libraries
- Thoroughly read and understand the documentation
- Know what libraries are available (or search)

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Knowledge of miscellaneous topics

Just a few examples:

- Regular expressions
- Floating point arithmetic
- Encodings
- Time zones
- Cryptography
- Commonly used protocols, such as HTTP, DNS, IP, TCP vs UDP
- Concurrency and parallelism, synchronization primitives
- Data structures and algorithms
- Databases
- Operating systems, HW

Interface design

- *Make interfaces easy to use correctly and hard to use incorrectly.*
  – Scott Meyers
- Your public interface should be crystal clear
- Aim for having a consistent interface

```
// Inconsistent position of parameters
int fputs(const char *s, FILE *stream);
int fprintf(FILE *stream, const char *format, ...);

// Inconsistent naming
#include <sstream>
std::stringstream s;

// Duplicities
size_type size() const;
size_type length() const;
```

Coding conventions

- Satisfaction of style guides and code conventions
  - Spaces vs tabs
  - Naming of variables (`snake_case` vs `camelCase`)
  - Code formatting in general (e.g. placement of curly braces, line wrapping)
- Uniformity is king
- Pay attention to detail
- Check typos and grammar in strings/comments

Performance

- What is an optimization?
- Typical optimization areas
  - Execution time
  - Memory usage
  - Response times
  - Throughput
  - Network communication
- Effectivity vs efficiency
- Golden rule: Do not optimize
- Understand trade-offs
- Always do profiling and perform benchmarks (avoid *pessimization*)
- Do not write needlessly inefficient code
- Know your language, compiler, operating system, architecture, etc.

Petr Zemek: Optimalizace kódu (FIT, 2013)

Selected techniques

Pull requests and code reviews

The "lone wolf" workflow:

1. Put all your changes directly into `master`

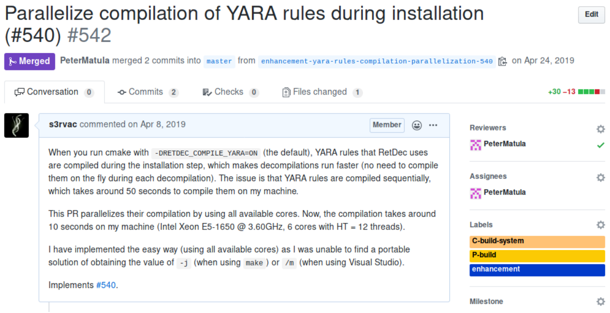
   (There is no step 2)

A more cautious workflow:

1. Create a new branch from the current `master`
2. Implement the needed change there
3. Push the branch and create a *pull request* (PR) from it
4. Make the PR pass through a *code review* (CR)
5. The PR is approved and the branch is merged into `master`

What is a pull request (PR)?

- A request to review your changes and merge them
- Most commonly associated with PRs on GitHub:



Parallelize compilation of YARA rules during installation (#540) #542

PeterMatula merged 2 commits into `master` from `enhancement-yara-rules-compilation-parallelization-540` on Apr 24, 2019

s3rvac commented on Apr 8, 2019

When you run cmake with `-DRETDEC_COMPILE_YARA=ON` (the default), YARA rules that RetDec uses are compiled during the installation step, which makes decompilations run faster (no need to compile them on the fly during each decompilation). The issue is that YARA rules are compiled sequentially, which takes around 50 seconds to compile them on my machine.

This PR parallelizes their compilation by using all available cores. Now, the compilation takes around 10 seconds on my machine (Intel Xeon E5-1650 @ 3.60GHz, 6 cores with HT = 12 threads).

I have implemented the easy way (using all available cores) as I was unable to find a portable solution of obtaining the value of `-j` (when using `make`) or `/m` (when using Visual Studio).

Implements #540.

Reviewers: PeterMatula ✓
Assignees: PeterMatula

https://github.com/avast/retdec/pull/542

- Note: Called a *merge request* (MR) in some systems

What is a code review (CR)?

- A process of looking at another person’s code and checking if it is correct
- Consists of:
  1. Writing comments towards the code
  2. Giving evaluation (approve or request changes)
  3. Discussing comments with the author

Reasons for creating PRs and doing CRs

- Finding bugs and other defects
- Learning something new
- Increasing the sense of mutual responsibility within your team
- Finding a better solution
- Running automated checks before the code is merged
- Writing better code
- and more...

Petr Zemek: Pull requesty a revize kódu (IVS 2020)

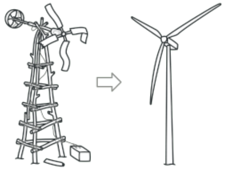
Pair programming

- Two programmers work together at one workstation
- Roles: driver and navigator
- Increased person/hours vs fewer defects
- Knowledge sharing
- Remote pairing
- Mob programming

https://bit.ly/3nyhDYe

Refactoring

- Restructuring existing code without changing its external behavior
- Code smells
- Improves maintainability and extensibility
- When to refactor
- Requires having tests
- Not all changes are refactorings
- https://refactoring.guru/refactoring



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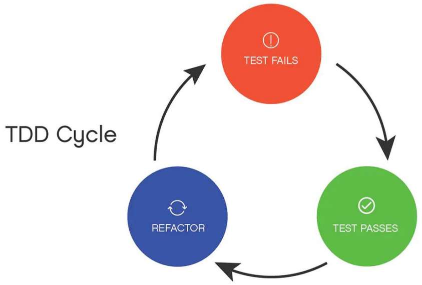
Test-driven development (TDD)

- A software development practice
- Clean code that works
- Leads to testable code
- Writing the interface you wish you had
- Seeing the test fail is important
- Do not refactor when your tests are failing
- Tests are already written when the code is finished



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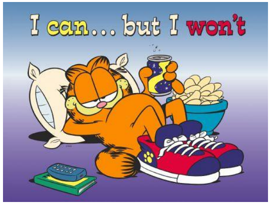
Anti-patterns

What prevents programmers from writing high-quality code

- Inexperience
- Laziness
- Disinterest, unwillingness to learn
- Lack of sense for detail, sloppiness
- Bosses or coworkers
- Circumstances (e.g. deadlines)



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Cargo cult programming

- A ritual inclusion of code that serves no real purpose

```
with open('file.txt') as f:
    data = f.read()
    f.close()
```

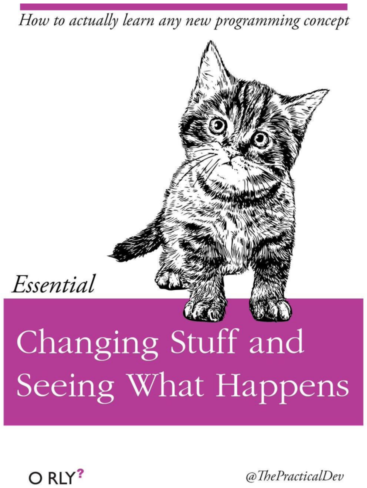
- Copy-and-paste programming
- Blind following of practices
- Some cargo culting might be unavoidable

```
public static void main(String[] args)
```

https://bit.ly/3gMTCLH

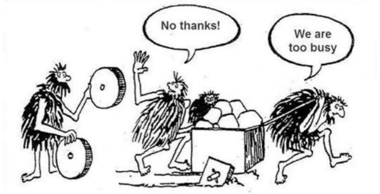
Voodoo programming

- Example: `if x > 1` (fail)
    - `if x >= 1` (fail)
    - `if x >= 0` (fail)
    - `if x < 1` (pass)


How to actually learn any new programming concept
Essential
Changing Stuff and Seeing What Happens
O RLY?
@ThePracticalDev

https://bit.ly/335UClK

Not invented here (NIH) syndrome



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- Let's write our own HTTP library; how hard could it be?
- But by reinventing the wheel, I will learn; or not?!
- Possible issues with software licenses or patents
- Beware of blind inclusion of third-party projects (security)

Recommended reading and summary

Recommended reading

- A. Hunt, D. Thomas: The Pragmatic Programmer (2nd edition), Addison-Wesley, 2019
  In Czech: A. Hunt, D. Thomas: Programátor pragmatik, Computer Press, 2007
- S. McConnell: Code Complete (2nd edition), Microsoft Press, 2004
  In Czech: S. McConnell: Dokonalý kód, Computer Press, 2006
- R. C. Martin: Clean Code, Prentice Hall, 2008
  In Czech: R. C. Martin: Čistý kód, Computer Press, 2009
- M. Fowler: Refactoring: Improving the Design of Existing Code (2nd edition), Addison-Wesley, 2018
  In Czech: M. Fowler: Refaktoring: Zlepšení existujícího kódu, Grada, 2003
- K. Beck: Test Driven Development: By Example, Addison-Wesley, 2002
  In Czech: K. Beck: Programování řízené testy, Grada, 2004
- S. H. Huseby: Innocent Code, John Wiley & Sons, 2004
  In Czech: S. H. Huseby: Zranitelný kód, Computer Press, 2006

A bit of harmless self-promotion (my blog posts)

- Petr Zemek: Čistý kód, který funguje (2009-10-24)
- Petr Zemek: Vysoce kvalitní kód (2014-04-18)
- Petr Zemek: Důvody, proč psát jednotkové testy (2014-06-20)
- Petr Zemek: Zakomentovaný kód (2014-11-02)
- Petr Zemek: Proč psát kód na jedné úrovni abstrakce (2015-02-21)
- Petr Zemek: Udržitelný vývoj (2015-03-15)
- Petr Zemek: Proč rozlišovat jednotkové a integrační testy (2015-04-18)
- Petr Zemek: Proč vytvářet funkce (2019-07-27)
- Petr Zemek: Série "Chyby v návrhu"
- Petr Zemek: Série "Ještě jednou a lépe"

Summary

- High-quality code provides many benefits
- We (as professionals) should strive to write high-quality code
- There are many aspects of high-quality code
- There are techniques that can help us achieving high-quality code
- There are also anti-patterns that hinder our efforts
- Many books have been written on this topic
- Code quality is not binary or absolute
- Perfection is not attainable